# PATENT SPECIFICATION (11) 1 482 411

(21) Application No. 25220/73 (22) Filed 25 May 1973 (19)

(23) Complete Specification filed 30 July 1974

(44) Complete Specification published 10 Aug. 1977

(51) INT. CL.² H02K 9/19

(52) Index at acceptance
H2A 13D 13X 2C2 2CX 2E12B 2E4A 2E4Y 2EX 2K8 4B2 4X
F1C 2D
F4U 24A2 24B1



(72) Inventor ANTHONY FAITHFULL ANDERSON


## (54) ROTARY MACHINE HAVING A COOLING SYSTEM FOR CIRCULATION OF LIQUID COOLANT TO THE ROTOR


(71) We, INTERNATIONAL RESEARCH & DEVELOPMENT COMPANY LIMITED, a British Company, of Fossway, Newcastle-upon-Tyne, 6, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—


The present invention relates to cooling systems for the circulation of liquid coolant to the rotating parts of rotary machines, for example elements carried by the rotor of a dynamo-electric machine.

Liquid cooling of conductors carried by dynamo-electric machine rotors has received considerable attention in recent years as machine ratings of, for example, turbo-generators, have increased. Novel types of machines, such as superconducting homopolar machines, have also led to the requirement for liquid cooling of rotor-borne segmented slip-rings.

Most liquid cooling systems so far proposed have required the inclusion of high pressure rotary seals to prevent undesirable liquid leakage owing to the high pressure required for circulation of cooling liquid against centrifugally induced pressure heads. The present invention seeks to provide an effective means of circulating cooling liquid through a rotating structure in which mechanical pumping of the liquid is effected but the requirement of rotary seals is avoided.

In accordance with the present invention there is provided a rotary machine having a rotor and a cooling system for the rotor or elements carried thereby, the cooling system comprising a closed circuit for liquid coolant including a rotary pump for circulation of the coolant and a heat exchanger for dissipation of heat from the coolant, the pump having an impeller rotatably mounted in a casing, the casing being connected for rotation by the rotor, and the impeller being constructed for interaction with a field of force acting through the casing such that upon rotation of the rotor there is relative rotation of the impeller and the casing.

The invention is primarily concerned with machines in which liquid coolant is used throughout the cooling system but it is also possible for the cooling system to include portions in which the coolant is in the vapour phase or to include one or more heat pipes which are in heat-exchange relation with the liquid coolant circuit.

In one form of the invention the impeller has its centre of gravity eccentric to its axis of rotation and is thus restrained against rotation by the gravitational field. The axis of rotation of the impeller coincides with the axis of rotation of the rotor and the offset of the centre of gravity from the axis may be achieved by adding an eccentric mass to the impeller or by constructing the impeller with blades of different masses.

In another form of the invention the field of force is a magnetic field instead of the gravitational field and the impeller carries an armature for interaction with the field of a magnetic field system arranged outside the casing. The armature may be permanently magnetised and may either be held stationary by the magnetic field or caused to rotate in opposition to the rotation of the rotor. Rotation may be effected by mechanical rotation of the magnetic field system or by rotation of the magnetic field by means of an electromagnetic field system. Rotation of an armature which is not permanently magnetised can be effected by making the armature the rotor of a motor of the reluctance or induction type, the stator of the motor being mounted around the casing.

The invention will be described in more detail with the aid of examples illustrated

in the drawings accompanying the Provisional Specification, in which:—

Fig. 1 is a schematic side view of a dynamo-electric machine with a cooling system in accordance with the invention,

Fig. 2 is a simplified cross-section of the pump for circulation of the coolant which is used in the machine of Fig. 1, and

Figs. 3 and 4 are cross-sections similar to Fig. 2 of alternative forms of pump which may be substituted for that of Fig. 2.

In the machine shown in Fig. 1, a stator 1 carries a stator winding 2 which surrounds a rotor 3, the rotor being supported on the stator by end bearings. Elements carried by the rotor, such as conductors or slip-rings, which for the sake of clarity have been omitted from the drawing, are cooled by means of a liquid coolant circulated by way of ducts 4 in a closed circuit between the rotor 3, a heat exchanger 5 for dissipation of heat removed from the rotor, and a circulating pump 6 which is mounted at the outer end of the rotor shaft.

Referring to Fig. 2, the pump 6 consists of an impeller 7 mounted on an outer casing 8 by means of bearings which allow relative rotation of the impeller 7 and the casing 8. The casing 8 is fixed to and rotates with the rotor shaft 9. The impeller 7 carries an off-axis mass 10 which is acted on by the gravitational field to restrain the impeller 7 against rotation when the casing 8 rotates with the rotor shaft 9. The resulting relative rotation of the casing and the impeller is sufficient to effect the required pumping of the coolant through the ducts 8.

In the alternative form of pump shown in Fig. 3 the impeller 7 carries a permanently-magnetized armature 11 which co-operates with a magnetized yoke 12 mounted outside the casing 8. The yoke 12 may be a permanent magnet or an electromagnet. If it is held in a fixed position the interaction of the magnetic field of the yoke 12 with the armature 11 restrains the impeller against rotation in a manner similar to the action of the gravitational field in the embodiment of Fig. 2. The yoke 12 can be rotated by a motor 13 in a direction opposite to the rotation of the rotor 3 and casing 8 and this will cause rotation of the impeller 7, thereby increasing the speed of relative rotation of the impeller and the casing and thus providing more rapid circulation of the coolant.

In the embodiment of Fig. 4 the magnetic yoke 12 is replaced by a stationary field coil 14 which encircles the casing 8 and is supplied with current in such a way as to generate a rotating magnetic field which drives the armature 11 and thereby rotates the impeller in opposition to the main rotor.

WHAT WE CLAIM IS:—

1. A rotary machine having a rotor and a cooling system for the rotor or elements carried thereby, the cooling system comprising a closed circuit for liquid coolant including a rotary pump for circulation of the coolant and a heat exchanger for dissipation of heat from the coolant, the pump having an impeller rotatably mounted in a casing, the casing being connected for rotation by the rotor, and the impeller being constructed for interaction with a field of force acting through the casing such that upon rotation of the rotor there is relative rotation of the impeller and the casing.

2. A rotary machine as claimed in claim 1 in which the impeller has its centre of gravity eccentric to its axis of rotation whereby interaction with the gravitational field restrains the impeller against rotation with the casing.

3. A rotary machine as claimed in claim 1 in which the impeller carries an armature for interaction with the field of a magnetic field system arranged outside the casing.

4. A rotary machine as claimed in claim 3 in which the magnetic field system is constructed to produce a rotating magnetic field which effects rotation of the impeller in opposition to the rotation of the rotor.

5. A rotary machine as claimed in claim 3 or 4 in which the impeller armature is permanently magnetized.

6. A rotary machine having a cooling system substantially as described with reference to Fig. 1 with Fig. 2, 3 or 4 of the drawings accompanying the Provisional Specification.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings,
London, EC4A 1HN.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1977
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1482411 PROVISIONAL SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

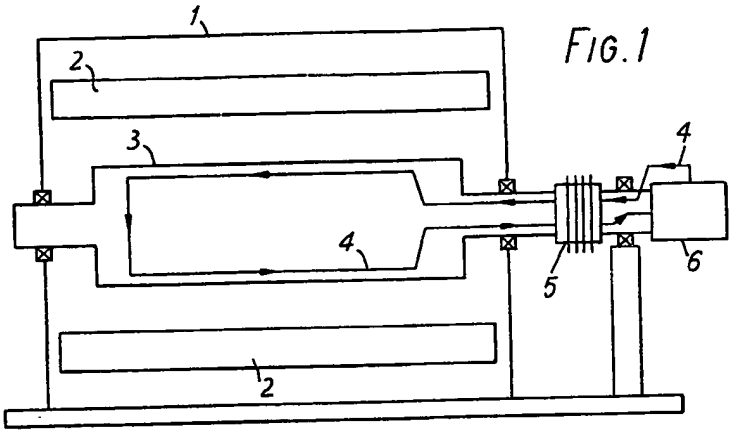


FIG.1

FIG.2

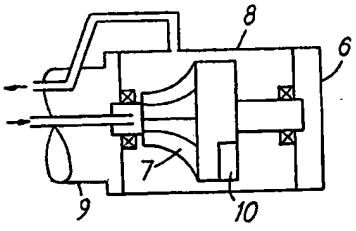


FIG.4

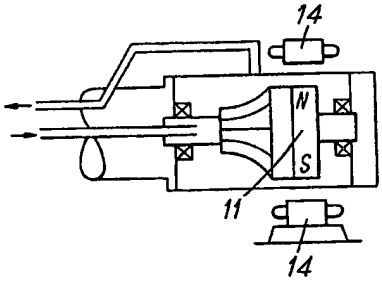


FIG.3